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A TRANSMISSION METHOD AND RADIO SYSTEM ADJUSTING TRANSMISSION MOMENTS

FIELD OF INVENTION

The invention relates to a transmission method used in a radio system that comprises at least one base station and a number of subscriber terminals, at least two of which transmit access bursts to one and the same base station, the access burst activating between a subscriber terminal and a base station a connection that is established by a signal that is of a certain frequency and is sent in time slots.

BACKGROUND OF INVENTION

Indoors, for example in office buildings, base stations suited particularly for the place concerned are used. The base stations receive and transmit a signal by means of RF heads. The RF heads of the base stations are positioned about the building so that the coverage areas of the base stations cover the whole building insofar as possible. In practice the RF heads comprise, for example, transceiver antenna units.

When an indoors radio system is designed, particular attention must be paid to matters affecting the propagation of the signal. The walls and other structures in the building may attenuate the signal very rapidly. The rapid attenuation of the signal may require a very dense base station network, whereby the RF heads are also relatively close to one another. Because of the large number of base stations, the system is relatively expensive to build.

The RF heads are positioned in suitable places about the building, whereby a connection can be established between a subscriber terminal and a base station. Because of the large number of RF heads, it has been possible to reduce the distance between the subscriber terminal and the RF head, which also reduces the delay from the RF head to the subscriber terminal.

The number of RF heads is normally larger than the number of base station transmitters. In addition, the number of transmitters is usually larger than the number of radio frequencies used at the base station. Let us assume that the subscriber terminals are connected with different RF heads of one and the same base station by means of a signal transmitted by them. If the subscriber terminals establish a connection with the base station by means of signals of the same frequency, interference may occur between the RF heads. The occurrence of interference is even more likely if the signals are transmitted using the same frequencies in the same time slots. The RF heads

receive the interference signal substantially simultaneously with the information signal, whereby the information signal is difficult to separate from the interference signal.

Radio systems typically employ a known training sequence, which is added to a burst to be transmitted. The training sequence is used to estimate the impulse response of the received signal. If both subscriber terminals use the same training sequence, it is difficult for the receiver of the base station to separate the information signals from the interference signals. In practice this means that the receiver is not able to separate the interference signal from the impulse response of the information signal estimated by it, whereby the quality of the signal is impaired. The problem can be solved by using signals of different frequencies on the connections, but the number of frequencies that can be used is, however, limited. If only signals of different frequencies are transmitted in the radio system, the costs of building the radio system are high.

In so-called office base stations intended for indoors, relatively low signal transmission power is used, since the RF heads are located in the vicinity of people. A sufficiently reliable estimate, however, is not achieved with the previously known methods because of the low transmission power, and this impairs the performance of the receiver.

BRIEF DESCRIPTION OF INVENTION

The object of the invention is to provide a transmission method and a radio system in which the above problems are solved. The object is achieved with a method described in the introduction, the method being characterized in that when the subscriber terminal is commanded to send the base station a signal that employs a time slot and frequency already used by another subscriber terminal, the subscriber terminal is sent a command to adjust the transmission moment of the signal so that the base station receives the transmitted signals at different moments.

The invention also relates to a radio system that comprises at least one base station and a number of subscriber terminals, at least two of which transmit access bursts to one and the same base station, the access burst activating between a subscriber terminal and a base station a connection that is established by a signal that is of a certain frequency and is sent in time slots.

The radio system is characterized by comprising transmission means, which command the subscriber terminal to send the base station a signal that employs a time slot and frequency already used by another subscriber terminal, and adjustment means, which on the basis of the command sent by the transmission means adjust the transmission moment of the signal to be transmitted to the base station so that the base station receives the transmitted signals at different moments.

The preferred embodiments of the invention are claimed in the dependent claims.

The basic idea of the invention is that the signals to be transmitted are delayed, if necessary, whereby an interference signal and an information signal can be separated from each other.

Several advantages are achieved with the transmission method and radio system of the invention. Since the signals transmitted at the same frequency can be separated after the signals have been received, the radio system can be implemented using a minimal number of different radio frequencies. The signals by means of which the subscriber terminals communicate simultaneously with adjacent RF heads can use the same frequency. This reduces costs when the radio system is built: for example, the number of transmitters can be reduced. In addition, signals can be received even at very low signal reception levels.

BRIEF DESCRIPTION OF FIGURES

In the following the invention will be described in greater detail in connection with preferred embodiments and with reference to the attached drawings, in which

Fig. 1 is a general view of a radio system in which a method of the present invention is used,

Fig. 2 is a general view of a structure of a transceiver used in the radio system of the invention,

Fig. 3 shows a radio system of the invention,

Fig. 4 is a more detailed view of the radio system of the invention, and

Fig. 5 shows a normal burst of the GSM system.

DETAILED DESCRIPTION OF INVENTION

Fig. 1 is a general view of a radio system in which a method of the present invention is used. The radio system comprises base stations 100, a base station controller 300 and subscriber terminals 201-203. The base stations are connected to the base station controller 300, for example, via a transmission line. The subscriber terminals establish a connection to the base stations by means of signals transmitted by them. The base station 100 usually forwards the signal transmitted by the subscriber terminal, for example, to another subscriber terminal. In practice, the base station 100 and the subscriber terminal 201-203 operate as transceivers.

Fig. 2 is a general view of a structure of a transceiver used in the radio system of the invention. The base station and the subscriber terminal comprise, in principle, the structures shown in Fig. 2. The transceiver comprises an antenna 108, which operates as a transceiver antenna. In addition, the transceiver comprises radio frequency parts 112, 124, a modulator 123, a demodulator 113 and a control block 120.

The transceiver further comprises an encoder 122 and a decoder 114. The control block 120 controls the operation of the above transceiver blocks. The radio frequency parts 112 convert the radio frequency signal obtained from the antenna 108 to an intermediate frequency. The intermediate-frequency signal is supplied to the demodulator 112, which demodulates the signal. The demodulated signal is subsequently decoded in the decoder 114.

The encoder 112 receives a signal and transmits the coded signal to the modulator 123. The coding in the encoder 122 is implemented, for example, as convolution coding. The encoder 122 also, for example, encrypts the signal. Further, the encoder 122 interleaves the bits or bit sequences of the signal. The convolution-coded signal is then supplied to the modulator 123, which modulates the signal. The signal is then supplied to the radio frequency parts 124, which convert the modulated signal into a radio frequency signal. The radio frequency parts 124 transmit the signal by means of the antenna 108 onto the radio path.

Fig. 3 shows a radio system of the present invention. The radio system comprises a number of RF heads 161-167 and two subscriber terminals 201, 202. The radio system is particularly suitable for indoors, for example, for office buildings. In practice, the RF heads are positioned in the

rooms so that the signals transmitted via the RF heads cover the whole building insofar as possible. The radio system also comprises four transmitters 141-144, means 130, and connection means 150. In practice, the transmitters 141-144, means 130 and connection means 150 are located at the base station 100. In the radio system illustrated by the figure, the RF heads 161-167 are connected to the connection means 150 via a cable 170. The connection means 150 are further connected to means 130 via transmitters 141-144, means 130 providing an Abis interface between the base station 100 and the base station controller 300.

The base station 100 and the subscriber terminal 201, 202 are connected with each other by means of signals. In the radio system illustrated by the figure, subscriber terminal 201 is connected with RF head 166 by signal 211. Subscriber terminal 202 is connected with RF head 167 by signal 212. In the radio system of the figure, RF heads 166, 167 are adjacent RF heads, located relatively close to each other.

The subscriber terminal activates the establishment of the connection with the base station 100 by means of access bursts transmitted by it. The base station 100 receives the access bursts on a RACH channel (RACH = Random Access). After the reception of the access bursts, the base station controller 300 controlling the base station 100 of the radio system sends the base station 100 a signal activating the channel. A time division multiple access TDMA method is preferably used in the radio system, whereby the signals establishing the connection are transmitted in time slots. The number of simultaneous connections is increased in practice by transmitting signals at different frequencies.

Fig. 4 shows the radio system of the invention in greater detail. The radio system comprises transmission means 101 and correlation means 102. The transmission means 101 transmit commands to the subscriber terminal, and on the basis of the commands the subscriber terminal changes the frequency of the signal transmitted by it. The correlation means 102 form impulse responses from the signals received by the base station 100. In addition, the radio system comprises data storage means 103, which store information about the radio frequencies used in the radio system. In the radio system illustrated by the figure, means 101, 102, 103 communicate with the base station 100. In practice, means 101, 102, 103 are located at the base station 100.

The subscriber terminal 201 of the figure comprises adjustment means 205, which adjust the transmission moment of the signal transmitted by the subscriber terminal 201. The subscriber terminals transmit a training sequence in conjunction with the signals to the base station 100. On the basis of the training sequence received by the base station 100, the correlation means 102 connected with the base station separate from each other at least two signals that are of the same frequency and have been received from the same time slot.

With reference to Fig. 3, let us first assume that the number of radio frequencies used at the base station 100 is smaller than the number of the transmitters 141-144 contained in the base station 100. The figure shows that the subscriber terminals 201, 202 communicate with one and the same base station 100 via different RF heads. Let us further assume that the subscriber terminals use a similar training sequence, by which the impulse response of the received signal is estimated. If the subscriber terminals use the same frequency and time slot, interference may occur between the RF heads 166, 167. Let us assume that subscriber terminal 201 in the radio system produces an interference signal 311 that propagates to RF head 167. Let us further assume that subscriber terminal 202 produces an interference signal 312 that propagates to RF head 166.

The correlation means 102 select, on the basis of the correlation, the signal with the best quality or for example the highest energy, and the signal is then used as an actual connection-establishing signal. The signals generated on the basis of the correlation are also placed in so-called windows. The correlation means 102 compare the summed energies of the impulse responses of the signals placed in the windows, whereby the interference signals received by the RF heads can be detected. Also, the subscriber terminal producing the interference signal can be detected.

The subscriber terminal 201 can communicate with a plural number of RF heads simultaneously. On the basis of the correlation, the signals that have been received by the RF heads and have been transmitted by one and the same subscriber terminal can be detected. When the subscriber terminal 201 roams in the radio system, the base station 100 instructs the subscriber terminal 201, if necessary, to change the current RF head for another RF head. The change can be based, for example, on a correlation result. If the subscriber terminal 201 is connected with several RF heads, then the

subscriber terminal 201 preferably establishes a connection with the RF head from which the base station 100 has received the signal with the greatest power.

In the radio system illustrated by Fig. 3, the RF heads 166, 167 receive an interference signal substantially simultaneously with an information signal. Since both subscriber terminals 201, 202 use the same training sequence, it is difficult for the base station 100 to separate the information signals form the interference signals. In practice this means that the receiver of the base station 100 is not able to separate the interference signal from the impulse response of the information signal estimated by it, whereby the quality of the signal is impaired.

Let us assume that the transmission means 101 command the subscriber terminal to send the base station 100 a signal having a time slot and frequency that are already used by another subscriber terminal and that are stored in the storage means 103. The adjustment means 205 then adjust the transmission moment of the signal to be transmitted to the base station 100. The adjustment means 205 adjust the transmission moment preferably before an actual connection is established.

Fig. 5 illustrates, by way of example, a normal burst of the GSM system, the burst comprising so-called tail bits in two blocks 401, 407. There are six tail bits in all. The actual data is coded in two blocks 402, 406. Each block contains 57 data bits. The burst also comprises two 1-bit blocks 403, 405, which are used to detect signaling. The burst further comprises a previously known training sequence 404 in the middle of the burst. Further, the burst comprises a 8.25-bit guard period. In a normal burst the training sequence is 26 bits long. In the known solutions, such as in the GSM, the impulse response is estimated by cross-correlating the received signal samples with the known training sequence. From the 26-bit long training sequence, 16 bits are used to estimate each impulse response tap.

The adjustment means 205 use the tail bits 401 at the beginning of the burst to adjust the transmission moment of the signal. The guard period 408 at the end of the burst is also used to adjust the burst. The burst thus comprises exactly 11.25 bits that can be used in the adjustment where necessary. The adjustment means 205 thus delay or advance the transmission moment of the signal by substantially at most an 11-bit period. The adjustment of the signal to be transmitted allows the training sequences to

be received at different moments at the base station 100, whereby the signals transmitted at the same frequency and in the same time slot can be separated at the base station 100 by means of correlation. If the signal transmitted by the subscriber terminal interferes too much with a signal transmitted by another subscriber terminal, the transmission means 101 command the interfering subscriber terminal to change the signal transmission frequency.

In the radio system illustrated by the figure, the signals transmitted onto the radio path arrive at the receiver fairly rapidly, since the distance of the subscriber terminal from the RF head of the base station 100 is short. This means that the delay of the signal on the radio path is short. The short delay allows the estimated impulse response to be limited, for example, to a length of 3 or 4 bits. In practice the correlation means 102 limit the impulse responses to substantially 3 bits. If the adjustment means 205 adjust the timing of the subscriber terminal 201, 202, then the base station 100 can receive the signal, for example, at a delay of 4 bits, whereby the different impulse responses do not yet interleave. The adjustment means 205 thus adjust the transmission moments of the signals so that the base station 100 receives the signals transmitted by the subscriber terminal at different moments.

As stated above, the signals received by the base station 100 can be measured, for example, for energy. That signal received by the RF head 161-167 whose impulse response has the highest energy is defined on the basis of the measurement. The signals received by the RF heads 161-167 can also be compared such that the summed energies of the correlation taps of a desired signal are compared with the summed energies of the correlation taps of an interference signal. The following formula (1) is used to estimate the ratio of the summed energies:

$$estim\left(\frac{C}{I}\right) = \frac{\sum_i |h_i|^2}{\sum_j |h_j|^2} \qquad (1)$$

where

C is the strength of an information signal,

I is the strength of an interference signal,

h_i is the impulse response of a desired signal at an instant i,

h_j is the impulse response of the interference signal at an instant j.

Since the impulse responses of the desired signal and the interference signal are known, a so-called joint detection method can be used, and this further improves the performance of the receiver. The joint detection method, for example a JMLSE method, can be used, for example, to improve the bit error ratio of the signal.

Although the invention is described above with reference to the example illustrated in the attached drawings, it is to be understood that the invention is not limited thereto but can be varied in many ways within the scope of the inventive idea disclosed in the attached claims.